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Don't want grumpy spiders? Keep it cool

Life is always transitioning from one state to another. Some state transitions can be physical, such as the small Arctic fox changing its fur from brown to white when a snowy winter approaches, but they can also be behavioural, such as when my fellow humans grumble and complain about it being too hot or cold. To find out how thermal stress may affect transitions between different personality states, Grant Navid Doering from the University of California, Santa Barbara, USA, and a group of international colleagues turned to a spider, *Anelosimus studiosus*.

The animals have two very distinct and heritable personalities, aggressive and docile, both of which typically occur in a single colony. However, the aggressive spiders become more irritable as the temperature rises, so Doering and his team first created a computer simulation to determine whether these differing personalities may influence the response of the colony to changes in temperature. They included three behavioural states in their calculations – one for the docile individuals and two for the aggressive (relaxed and agitated) – in addition to various physical parameters, including temperature, colony size, the rate at which the spiders speed up as the temperature rises and how often a relaxed spider is aggravated by an agitated spider. The simulation suggested that the composition of personalities in the colony and the temperature influenced the number of agitated spiders; more grumpy spiders and a hot house resulted in even more grumpy spiders. The simulation also revealed that fewer spiders became agitated in smaller colonies because they bumped into each other less often than in larger colonies.

To test their simulation, Doering and his crew formed colonies of live spiders with group sizes of either 6 or 20 individuals with varying personality mixtures: only aggressive, only docile, or half of each personality. The team then subjected each of these manufactured spider colonies to a temperature cycle ranging from 27 to 33°C, warming the colony and then cooling it again several times. During these heating and cooling cycles the researchers watched and documented all of the interactions, cordial or hostile, between the spiders.

The team observed that at a specific temperature, which they termed the social tipping point, the spider colonies transitioned from a relaxed to an agitated state as the temperature rose and then calmed down as the mercury dipped below that level. However, this temperature differed between the aggressive and docile spider colonies. During the heating phase, aggressive groups became agitated and displayed violent interactions more quickly, i.e. at lower temperatures, in comparison to the docile groups. It also took longer for these aggressive groups to calm down during cooling. Interestingly, the temperature at which the agitated spiders mellowed during cooling was lower than the transition temperature during heating for the aggressive groups, suggesting it takes more effort for overheated and worked up spiders to chill out. This trend was similar in the small and large aggressive groups, although there were more occasions when the spiders bumped into each other in the larger groups. In contrast, the social tipping point for the docile colonies was similar during heating and cooling and between the group sizes. Strangely, the shift from mild to aggressive behaviour in the small mixed colonies was more similar to that of the aggressive groups, whereas the shift in the large mixed colonies was more similar to that of the small and large docile groups even though the social tipping point was lower. Although Doering and colleagues are not entirely sure why, they suggest that larger mixed colonies may cope better with thermal stress.

This exciting research shows that the personality types of spider colonies do not shift gradually from one to another, but they can transition suddenly when the temperature is just right.

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To stroll or to sprint? Humans consider time and effort

If you ever run late to the bus, you might decide to break into a sprint to catch it at the expense of entering with damp armpits, glowing cheeks and gasping for air. Had you had plenty of time, you could have strolled aboard and saved yourself the effort. Erik Summerside and his colleagues from the University of Colorado in Boulder, USA, wondered whether the trade-off between how people perceive the value of their time versus the energy that they exert to move quicker can explain how people decide whether to walk or run. They hypothesized that people would use a strategy that was sensitive to saving both time and energy and that the specific combination of the two strategies would vary between people.

To test this hypothesis, the team identified pairs of distances where individual athletes equally preferred walking (D_W) and running (D_R). The scientists determined D_W/D_R pairs by making the athletes run and walk to pairs of marker cones that were initially the same distance (e.g. 40 m) away from the start line. The team then adjusted the distance that the athletes walked to the second cone until the athletes' preferences for running to the 40 m cone and walking the adjusted distance to the second cone were identical. The team then repeated the process with each athlete over initial distances of 60, 80, 100 and 120 m before plotting the pairs of distances on a graph and looking at the slope of the line that they produced. Computer simulations by the team had already shown that a steep D_W/D_R slope indicated that the athlete had selected an energy-conserving strategy while a shallow slope indicated that the athlete had elected a time-saving strategy. By comparing the slopes of the athlete's plots with the simulations, the team could tell whether the athletes preferred to conserve energy when moving or save time.

After comparing the slope of the D_W/D_R plots for all 20 athletes with the simulated D_W/D_R plots for energy- versus time-conserving strategies, the team found that eight athletes tried to conserve energy, 11 tried to shorten movement time and a single athlete tried to move as fast as possible. This means that, as the team expected, the group of athletes didn't use the same single strategy. But when the team tested whether the individual strategies were based on only saving energy or only saving time, they found that the athletes used strategies that covered a range of combinations that were specific to each of them.

Next, the team wondered whether the athletes who wanted to save time had decided to move faster during the experiment. When the team compared the athletes' strategy with their speed, they found that athletes ran faster – but didn't walk faster – if they had put emphasis on saving time rather than energy.

Interestingly, the finding that walking speeds were confined to a narrow interval could be explained by the steep energy cost of walking at a speed that is not the individual's preferred speed – contrary to running, which only exerts a little extra energy away from people's preferred speed.

The observations made by Summerside and colleagues show that people consider saving both time and energy when they decide whether to walk or run. Their approach might also be a powerful way to understand how humans and animals perceive costs and rewards when they decide whether to invest time and energy into diverse movements such as foraging, exercise or even catching the bus.

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Pythons sacrifice muscle to provide water for their eggs

Animals – and their eggs – are over two-thirds water. However, many species inhabit regions in which water is scarce, at least seasonally. This makes water a precious commodity, particularly during reproduction, when it is time to invest in the next generation. To ensure the best start in life for their young, animals often aim to synchronise egg hatching with the start of the wet season. But this is a double-edged sword as egg development has to begin towards the end of the dry season, when times are most challenging for the mother. As a result, she may have to get resourceful.

To investigate how seasonal breeders cope with egg production during periods of water scarcity, George Brusch from Arizona State University, USA, and his colleagues studied female Children's pythons, a species adapted to the wet–dry climate of northern Australia. The team monitored the snakes throughout their 3 week gestation period, during which egg development takes place. They deprived half of the egg-laden pythons of water, while providing the remaining snakes with an unrestricted water supply, and compared these snakes with a cohort of females that were not preparing to reproduce, half of which were also water deprived.

To assess dehydration, Brusch and colleagues took blood samples and measured osmolality, which represents the concentration of dissolved materials (solutes, such as salts). An increased osmolality means an increased concentration of solutes in the blood, which is a hallmark of dehydration. They saw that both reproduction and water deprivation independently increased blood osmolality and that water-deprived egg-laden pythons became the most dehydrated. This confirmed that water limitations are indeed a problem for these snakes during reproduction.

The team also measured the width – as an index of muscle size – and body mass of the snakes over the duration of their study. According to both metrics, dehydrated animals withered away more than animals with access to water, providing evidence that muscle was being broken down. Protein breakdown provides an excellent source of water, so this represents an efficient reallocation of resources. Earlier work had already established that snakes and other animals break down protein to provide nutrients during reproduction, but this was the first time it had been linked to water provision.

Finally, the researchers asked whether the snakes' muscular sacrifice was enough to compensate fully for their lack of access to water. They found that the females that were deprived of water laid just as many eggs as those with water (about 12 in each case), but this wasn't surprising because the number of eggs carried by each female was probably determined before the experimental dehydration regime started. More importantly, however, the water-

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deprived females laid slightly lighter eggs than those provided with water. This may ultimately impact embryonic growth and hatchling performance, although the extent of this was not determined in the current study.

Muscle loss during reproduction has been documented from insects to birds and mammals, and although some of these animals inhabit dry environments, muscle had not been previously considered as a potential water source at times of drought. Of course, muscle loss is not trivial. In snakes, as well as other species, it is known that muscle loss during reproduction can negatively impact an animal's ability to move. Thus, it appears that successful reproduction may rely on a tricky compromise between resources for mother and egg, and this compromise is strongly influenced by the prevailing environmental conditions.

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